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CONTENTS.

PAGE

Council and Officers i

Committees ii

General Notices :—

Copyright iv

Issue of Journal iv

Changes of Address iv

To Authors of Papers iv

The Library v

Advertisements in the Journal xxiv

List of Advertisers xxiv

Personal Notes of Members xxiv

Editorial :—Advance, Stand or Retreat 65

Twenty-sixth General Meeting, 18th October, 1917 :—

Paper : The Prospective Oilfields of Barbados, by E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S. 68

Twenty-seventh General Meeting, 15th January, 1918 :—

Paper : The Petroleum Industry of Rumania, by Capt. T. S. Masterson, D.S.O. 79

Discussion : by the President, Messrs. W. E. Guttentag, L. Hamilton, L. Gaster, and D. A. Sutherland ... 94

Later notes : by Messrs. R. J. Ward and M. A. Ockenden 100

Periodicity in Spouters, by W. H. Dalton, F.G.S., F.C.S.... 104

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Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms etc., should be made to the Secretary.

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

Mr. J. E. M. Hall returned from New Brunswick in January.

Sir William Plender has received the additional honour of the Grand Cross of the British Empire.

Mr. G. B. Reynolds has left for Venezuela.

Mr. I. A. Stigand has returned from Trinidad.

Mr. Kenneth Watts is taking a course at the Engineers' Reserve, Officers' Training Camp, Virginia, U.S.A.

EDITORIAL.

Advance, Stand, or Retreat.

Which of these three policies will the members of this Institution elect to follow? The question is one of primary importance as we enter upon the fifth year of our existence.

We have attained a certain recognised standing amongst kindred Institutions, and, despite the smallness of our membership, the capacity of our active contributors has enabled us to render to the industry at large, to the British portion of it in particular, and even more directly to our country in the present critical period, what is admitted to be good service, though far short of what we could have desired to render.

Apart from matter published in the Journal, and collected in accessible form in the Library of the Institution, scarcely a day passes without inquiry either as to some item of fact, or for the most trustworthy source of fuller information, and not infrequently in respect of matters beyond the purview of the Institution, although cognate in character.

The central course recommended in a familiar Latin aphorism is hardly practicable under the present circumstances, viz., the retention of a stationary attitude in the torrent of so progressive an age. "To go backward is nothing but death," and therefore a third proverb may point out, in general terms, the best line of action, advance with caution. The skilled general will keep in touch with his base without unduly restricting forward movement.

In a large Society, of many years' standing, the existence of a very considerable proportion of members who are merely absorbents of interesting or valuable information, and who never attempt any but pecuniary contribution, is of minor importance by reason of the still large body of direct participants in the work of the Society. It is otherwise when the active element is so limited that it is unduly taxed to maintain the vitality of the corporation. The early years of the Institution have been marked by frequent times of anxiety lest the newly-launched craft should be wrecked, as Hood puts it, in "Babycome Bay," for lack of a sufficient A.B. crew. Navigation is enhanced in difficulty if the quarter-deck staff has to be continuously 'bout ship, and though we have thrice made the run to "Port Natal," and with comparative ease, we are still handicapped by shortage of adequate assistance in the direction of communications, for publication or otherwise, as well as of funds: we require more hands, and more stores.

As regards "hands," we require, and that urgently, a larger number of members able and willing to supply papers on branches with which they are *au courant*, and to act on Committees of investigation or otherwise, in such directions as may be desirable from time to time.

In respect to Committees, these have as a rule but a temporary existence, being constituted *pro re natâ*, and dissolved when their purpose is effected, or superseded by other considerations. They call for a variety of capacities, commensurately with their scope. Some may be appointed for investigation upon lines entirely new, others for verification or correction of reported results, upon the accuracy of which there remains doubt; and yet again others for the collection and co-ordination of data at present scattered through a variety of sources of information. Forecast of requirements in this direction is futile, but it is needless to insist upon the diversity of ability requisite for the functions of the Institution. Besides these needs for external activities, renewal of the internal energy, in administrative, financial and other directions, will be necessary from time to time, and devolution of management, like other changes, will be best effected gradually. Experience, not only in general principles, but of the special characteristics of the Institution, will be requisite for successful grappling with the difficulties confronting the execution of the fundamental purposes for which we are incorporated.

A further want is that of a larger circle of speakers to take part in the discussions at our meetings, that the list of such participants in the Contents of the Journal may be somewhat less monotonous than heretofore. Those who cannot be present, or for whose share in the discussions adequate time is lacking, we would again press to communicate in writing any critical or collateral remarks that may be desirable, no matter how belated such may be.

For replenishment of our stores, we want a wider membership, including students and others who have at heart the interests of the Petroleum Industry. Though the necessity of money to extend operations in the direction of increasing our library and facilities for its utilisation and in enlarging our Journal is a factor in our wish for large accessions to our membership, a more important consideration is that of the original founders of the Institution—the need of co-operation and co-ordination of energies of the many able engineers, chemists, geologists and others, previously, and still largely, carrying out their life-work independently and without the added power of combination, with the necessary result of falling short of their aims wherever that work comes into contact with

matters beyond the line of their individual experience. "More powerful by conjunction," the motto of the Institution, concisely expresses a world-wide truth, and the attention of the many whose interests would be advanced by association with the Institution should be drawn to it by those who, already within the pale, have felt the benefit of membership.

Besides our bank account and list of members, we also enumerate amongst the desiderated stores the accumulation of knowledge, as a foundation for useful action in the future. Whilst the progress of science and technical skill is so rapid that action on the lines of a few years back would be folly in many cases, the observations of careful students more than a century in age have still an appreciable value, and the more so as the verification of their record is in many cases defective in some detail that assists in the utilisation of the knowledge. For example, a modern writer may, in describing the mineral hydrocarbon of a little-known region, omit details of its mode of occurrence, carefully set forth long ago by an author who was incapable of chemically investigating the substance. The chemist regards only the sample: he may, for distinction, mention the country of its origin, but the details of its environment are trivial (to him) in comparison with its composition. Here comes in the value of a full bibliographic record, that all published particulars may be looked up when needed.

In respect of both old and new matter we would urge our members to be more communicative. Those whose observations are too far from completeness to form the basis of a formal paper on any branch of our wide-ranging subject, need not on that account abstain from notifying us of anything that seems worthy of record. Intimation of the publication of papers that furnish information of interest to us, but of which the title does not convey any connection with petroleum or its products, or which are of so limited circulation that we are unlikely to hear of them, will always be very acceptable, and copies thereof still more so.

We are fully aware of the many omissions from, and of not a few direct errors in, published bibliographies, the compilers of which have rarely been able to verify more than a large fraction of the collected entries. Every correction or addition in such cases is a definite step toward completeness, at least for the past. Those who have formed collections of works on their special branches, or have compiled, for private use, bibliographies of such branches, are invited to confer with the writer as to the best method of utilising the matter so amassed for the benefit of the Institution.

Twenty-Sixth General Meeting.

A Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2, on Tuesday evening, 18th December, 1917, Mr. Arthur W. Eastlake (Member of Council) occupying the Chair.

The Members of the Institution present were Messrs. W. J. A. Butterfield, E. H. Cunningham Craig, A. Lloyd Eastlake, E. Lawson Lomax, F. Russell, T. Schwarz and W. Sutton. A letter of regret for unavoidable absence was received from Dr. F. Mollwo Perkin.

Mr. Eastlake said that in the absence of the President he had been asked to take the Chair. On account of the air-raid then in progress, he would move that Mr. E. H. Cunningham Craig's paper on "The Prospective Oilfields of Barbados" should be taken as read, and the discussion postponed till the next, or some future meeting.

Mr. Lomax seconded the motion, which was unanimously agreed to, and the meeting terminated.

The Prospective Oilfields of Barbados.

By E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S., *Member*.

It is not proposed to give in this brief paper a full account of either the geology of the island, or the praiseworthy attempts that have been made to prove its oil resources.

The geological features are well known, chiefly by the excellent work of Prof. B. Harrison and the late Mr. A. J. Jukes-Browne, while many writers and observers have dealt with the subject of Barbados petroleum from various points of view.* A careful geological survey on the scale of six inches to the mile has been made of all parts of the Colony, where evidence concerning the petroliferous strata is available, and the official report embodying the results of that survey gives all necessary details.

Nor is it intended to deal with the subject historically, giving each scene in the drama, whether tragic or comic, of attempted development. All this has been recorded, from the earliest mentions of "green tar" and manjak (or "munjac," as it used to be called) to the present day.

It is proposed rather to dwell upon some of the less obvious features of geological interest as displayed in the island, and to

*See bibliography above, pp. 63, 64.

consider Barbados, not as an area apart, but in connection with phenomena of earth-movement, deposition and denudation, as revealed by the study of the region in which it is situated.

Similarly, the development of the prospective fields will be considered, not as a matter of local interest, but as part of a scheme of Imperial development of resources, in the hope of contributing, in however small a degree, to the disintegration of those time-honoured parochial ideas from which British national affairs have suffered so severely in the past, and from the deadening effect of which broader and more comprehensive views are believed to be gradually but surely emerging.

Geological Structure.—As is well known, there are three distinct geological formations in Barbados, in ascending order, the Scotland Beds, a littoral, estuarine and deltaic group of strata (probably of early Tertiary age according to the latest evidence), the Oceanic Beds, and the Coral Limestone.

The Oceanic Beds, probably of Miocene and later age, overlie with an unconformability, which is not always very obvious or very pronounced, the Scotland Beds, while the Coral Limestone of Recent age overlies both with a most distinct and striking unconformability. Just as these later formations conceal the petroliferous Scotland Beds, and make it exceedingly difficult to read their history, so the importance of the prospective oil-fields of Barbados has been overlaid and concealed by the more obvious immediate interests of the Colony, and what has been accepted as axiomatic concerning them.

The island lies upon the outer rim of the great Caribbean basin, the tectonic features of which have been admirably explained by R. T. Hill and others. This outer rim, obviously a recent earth-fold of considerable importance, curves round from an off-shoot of the Andean chain in Colombia and Venezuela through Trinidad, Tobago and Barbados to Barbuda, and so through Anguilla and the Virgin Islands to Porto Rico, San Domingo and Cuba.

Within this outer ring comes the well-known parallel volcanic ring from Santa Margarita through Grenada, St. Vincent, St. Lucia and the Leeward Islands to St. Kitts. Chains of reefs and shallow soundings emphasise the concentric arrangement of earthfolds that encircle the deep basin of the Caribbean Sea on the southern, eastern and northern sides.

A study of the main strike lines of the folding in Venezuela and Trinidad proves clearly how the most detailed and intimate foldings conform to this broad and simple arrangement. In Venezuela the Post-Tertiary folds lie east and west, curving to south-west near the Colombian border, while in Trinidad the earlier east-and-west

folding gradually gave place to movement that developed flexures running slightly north of east to south of west in those areas where freedom of movement was still possible.

In Barbuda the Recent coral formation obscures all trace of older strata and Tertiary folding; but Barbados comes in as a very important link in the chain, exactly where such evidence is required, and makes it possible to read a further chapter of earth-history.

The island is built upon and round a core of intensely folded beds of the Scotland series, the strata being arenaceous below and more argillaceous in the higher horizons. Probably not much more than half of what might have been a larger island now remains, for the tides and currents, attacking constantly from the eastward

FIG. 4.—Sketch-map of Caribbean Region.

and north-eastward under the impulsion of the Trade winds, have breached the outer defences, and cut deep into the central core, thus allowing subaerial denudation to lay bare a large area of the pre-Coral formations.

The major folds, where they are best seen, strike E. 20° N. and W. 20° S. The general south-westerly pitch of the folding—especially towards the centre of the island—indicates how large a part of the central core has been removed by denudation. This folding evidently commenced not long after the deposition of the sediments, which were probably derived from the debris of a land surface lying to the eastward and southward. Indications of land in that direction can also be deduced from the study of the Tertiary

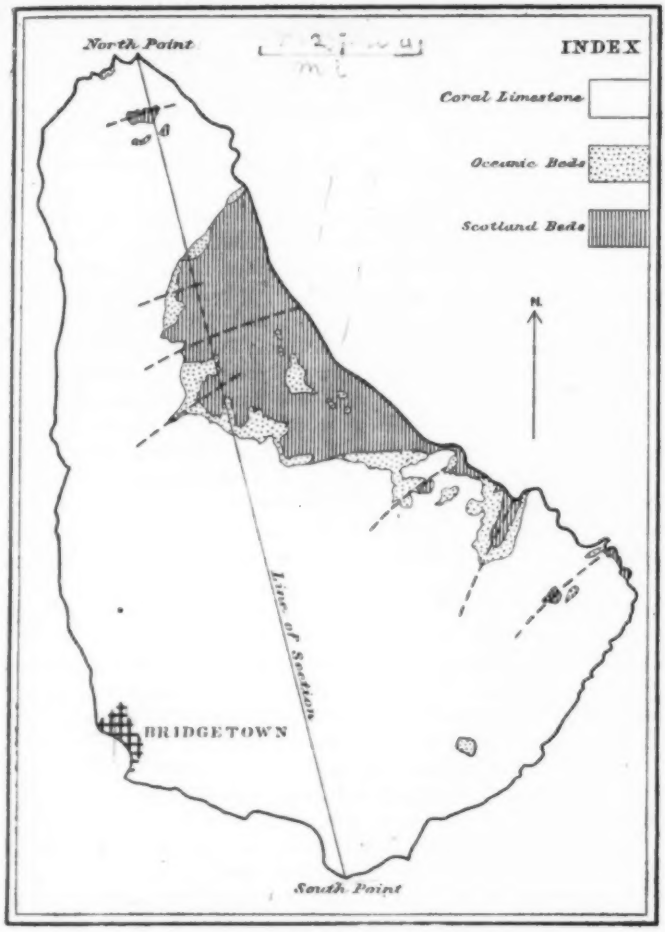

FIG. 5.—Geological Sketch-map of Barbados.

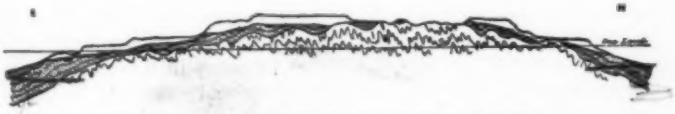

FIG. 6.—Diagrammatic Section, S.S.E.–N.N.W

strata of Trinidad, and it is probable that the Scotland series is only a minute part of a widespread formation.

Simultaneous with the earliest folding, or immediately following it, the area began to sink in the trough of a great earth-wave. At the commencement of this trough-subsidence, denudation of the folded Scotland Beds took place, but as the movement continued, the zone of denudation was passed through, and formation of Oceanic deposits ensued.

It must be remembered that the strata now forming the island had not yet reached their present geographical position, but were probably some distance to eastward and southward. A period of quiet, steady deposition followed in a clear and deep sea, the foraminiferal and radiolarian marls gradually forming over a wide area. At this time the same trough of the earth-wave affected conditions in what is now the island of Trinidad. The trough was here neither so deep nor so extensive, but the great marl beds of Naparima, reaching a thickness of perhaps 2,000 ft., indicate a period of undisturbed deposition in as clear but not so deep a sea as that of which the Barbados deposits give evidence. Towards the south and east of Trinidad also, we find indications of an approach to land in pelagic rather than oceanic deposits, and occasionally even the farthest-flung vestiges of deltaic conditions.

One very interesting point to note is that though Barbados and Trinidad were deep in the trough of the earth-wave, a little farther to the westward the crest of the wave had probably reached the surface of the waters; the vulcanicity which is still in evidence in Martinique and St. Vincent had commenced, and fine volcanic ashes occasionally mingle with the Oceanic marls in Barbados. In Trinidad no such evidence has yet been recorded.

The next period of which we have record is again one of extensive movement. The trough of the earth-wave had passed, and the outer rim of the basin began to rise on the crest. A distinct and considerable folding movement accompanied this gradual elevation; indeed, the lateral thrust that caused the folding had probably the effect of bringing the strata that now form Barbados from a position in the trough gradually up the rising slope of the crest.

The effect of this movement is seen in the folding of the Oceanic Beds into well-defined and fairly steep, but not very extensive, anticlines and synclines. The direction of movement, however, was not the same as in the earlier movement. The new flexures are orientated N.E. and S.W., with a tendency in the latter stages to diverge still more towards a northerly and southerly direction. The relation of the locality to the great concentric rings of the

earth-waves makes it inevitable that such a gradual change in direction of thrust must have taken place. In what is now Trinidad the direction of movement at the same time was also changing, and where the strata had still some freedom of movement, the strike-lines developed in a direction considerably north of east to south of west.

The effect of this oblique movement upon the earlier folds of the Scotland Beds was just what might have been expected. The major folds were compressed more acutely, the less sharply folded areas were bent into northeast and southwest flexures, and a certain amount of minor faulting, chiefly strike-faults of the later stages of the flexuring, enabled the older strata to adjust themselves to the altering conditions.

Meanwhile, the outer rim of the Caribbean basin was rising slowly and steadily, and the land-surfaces to eastward and southward had disappeared in another trough. In due time Barbados may be said to have been born, first as a coral reef, the folded mass of strata having been brought upward to the depth at which coral can grow. Much denudation of the soft Oceanic deposits certainly took place during this elevation, and the first fringing reef of coral dipped gently seaward from a planed-down surface of both Oceanic and Scotland Beds. Thereafter, Barbados rose majestically from the waves in successive stages, each marked by its horizontal coral terrace, till it has reached in Mount Hillaby a height of 1,105 ft. above sea-level. It is possible that the movement of elevation has not yet ceased, and Barbados may yet grow larger by successive additions of coral terraces, one of which is now an outlying reef. That the earth movement has not yet ceased in Trinidad is demonstrable, but it is there marked by a tilting of the northwestern corner downwards with a corresponding elevation of the northeastern corner, and a perceptible accentuation of the latest anticlinal and synclinal flexures.

It is impossible to give the sequence of events on the northern margin of the Caribbean basin without detailed geological work in Porto Rico and San Domingo and Hayti, but the presence of Barbuda and the Virgin Islands shows a similar gradual elevation in Recent and sub-Recent times.

Along the southern margin the great post-Tertiary folds and the Recent coastal plains carry on the story of this great crustal movement, and the soundings in the Caribbean indicate the complementary depression.

The chain of volcanic islands on another crestal ring, possibly along a great line of fissure, attained at the same time their present

importance, and volcanic ashes are still strewn broadcast to mingle with the Oceanic deposits that are forming in the zones of depression.

Prospecting Areas.—Thus out of the tribulation of earth forces was Barbados formed, and the few fragmentary paragraphs of earth-history that we have been able to decipher by laborious field-work might well have remained untranslatable, had not Barbados furnished the key to nature's cryptogram.

It follows now to apply the knowledge that has been acquired of this romance of earth-history to the very practical question of oil-field development. In Barbados this is by no means so simple a matter as in most oilfields.

The facts to be considered are as follows:— Everywhere where the Scotland Beds are exposed there are traces of petroleum. In many cases there are good seepages of heavy oil, there are innumerable outcrops of oil-sand, more or less dried up, in two or three localities the presence of manjak veins gives evidence of petroleum at greater depths, and there is one natural gas well, the long-known "Boiling Spring."

But the Scotland Beds present no broad, well-defined anticlines for testing; the folding is very sharp and irregular, and the dips steep, and though the upper beds are largely argillaceous, they have frequently been denuded and so cannot have served to seal up stores of petroleum, except in a very minute and local manner.

Practically every attempt to win oil has been made in the vicinity of outcrops of oil, and where the petroliferous beds are fully exposed and dipping very steeply. All such attempts have attained a measure of success, an asphaltic oil, sometimes heavy and sometimes light, having been obtained in quantity sufficient to encourage the prospectors, but the yields soon fell off to an unremunerative total, and, though I believe one or two wells are still being pumped occasionally, the production of oil is negligible.

The problem is to find localities where the Scotland Beds, however sharply and irregularly folded, have been preserved from excessive denudation and inspissation, and where there is some hope of a sufficient concentration of petroleum contents to give production of commercial importance.

It is evident that later or post-Oceanic flexures must be of much greater importance in this connection than the earlier folding. To begin with, it is broader and more gentle. Again, the Oceanic Beds, if not entirely denuded, must have some effect in sealing up petroleum in the Scotland series beneath them. Also the anticlinal flexures of the Oceanic Beds must have affected the underlying strata.

It became necessary, therefore, to trace out the broadest and best defined of the post-Oceanic flexures, and by a study of their orientation to follow them beneath the capping of coral that wipes out all evidence of the older rocks. This can only be done very imperfectly at present, since there are no deep drilled wells to guide the prospector, but by the help of water-wells and isolated outcrops, and keeping constantly in mind what has been learnt of the earth-movements and their variations in direction and intensity, it has been possible to indicate, over a considerable portion of the island, the lines upon which development work should be conducted, working always from the known to the unknown, feeling the way gradually from well-ascertained to problematical conditions.

It may be stated at once that there are several small areas where the prospects of obtaining petroleum in fair quantity are distinctly bright. In each parish in which development work of any kind can be recommended, the prospecting areas have been classified *a*, *b* or *c*, according as prospects appear more or less favourable.

The order in which prospecting wells should be drilled has been given, the depths to which such wells should be drilled have been suggested—though it is hoped that much deeper drilling may be required some day—the special difficulties in such cases have been indicated, and short of actually locating the wells, all advice that it seemed possible to give in the special circumstances has been given.

The report on the Oilfield survey has been published, but the prospecting areas have only been published on a small-scale map. The 6-in. maps have not yet been published.

It is not suggested that there can ever be a great and prolific oilfield in Barbados; but there is every probability of moderate productions being obtained in the most favourable localities. Should success attend the first efforts to follow up oil on a careful and well-thought-out scheme, a prosperous little industry might easily be established; and, conversely, should failure attend such efforts it will be as well to know the truth as soon as possible. If all the innumerable evidences of petroleum in the island are merely snares for the unwary scientist and capitalist, the sooner their true significance is realised the better.

Development Work.—A few words are necessary to describe the development work that has actually been done. This work is indissolubly associated with the name of the Hon. A. C. Ponsonby, whose plucky and long-continued efforts to found a petroleum industry have perhaps hardly received adequate recognition.

Fourteen wells in all have been drilled, but not all of these have

been carried to sufficient depths. There have also been a number of shallow prospecting wells, from which small supplies of petroleum have been obtained.

The area that has been most fully prospected is at Turner's Hall, where eight wells of various depths were drilled. These are unfortunately rather close together, and have not served to develop any large area. They are drilled in the Scotland Beds where the dips are steep, and the folding acute and irregular. The best year's production from all wells, exclusive of the shallow prospecting bores, comes out at an average of two barrels per well per day. The oil is a fairly high-grade petroleum of asphaltic base, mobile and containing a good percentage of light oils.

The point to note is that if such results could be obtained under very unfavourable geological conditions, there is every probability of obtaining good results when more carefully selected areas are tested.

The great difficulty that has beset all attempts to develop the Colony's oil resources has been in obtaining the right to prospect over a large and compact area. The island is all freehold property, divided into a very large number of small estates, all carrying full mineral rights. Thus, to obtain the right to prospect over a large area necessitates negotiations with a large number of separate proprietors, each of whom naturally has his own interests to conserve, and his own ideas as to how oilfield development should be conducted. Every private attempt to get a number of proprietors to combine has ended in failure.

Legislation has been resorted to, and various Acts have been passed to favour the development of a petroleum industry: but, in some cases, the Act took away with one hand the rights it conferred with the other; and in spite of careful and lengthy discussion, no Act yet passed has had any practical effect in stimulating development.

There are several ways in which active prospecting could be ensured; but all entail some form of monopoly and some measure of compulsion on the proprietors of land. It would be possible to grant by legislation to one of the powerful groups of petroleum capitalists the exclusive right to prospect for, win, transport and refine oil in the Colony. This would probably have an immediate effect, and would ensure the most efficient and up-to-date methods of exploitation, but it would put the Colony entirely in the hands of one Corporation. There is not the slightest likelihood of such a method being favoured by the Barbadian community.

Another method would be to grant a monopoly of pipe-lining and

refining to an Oil Company or Syndicate, and permit each proprietor to make his own arrangements for developing his own land. This might have the desired effect, but still some combination between proprietors would be necessary to make it worth while for any company to drill. If this method had really far-reaching effects, it would probably result in the monopoly of refining and transport controlling everything. No one likes the sound of the word monopoly, and this scheme has little chance of being considered favourably.

Possibly the most hopeful method was that suggested by Sir Leslie Probyn. In this scheme each parish, of which the island contains eleven, was to be considered as a separate area, and development Companies allowed to apply for the exclusive right to prospect a parish. Trustees were to be appointed to safeguard the interests of the proprietors in each parish, and in the event of prospecting with the drill giving successful results, the Company would select the particular areas they wished to work, and pay royalty to the proprietors whose land they were developing. This scheme was carefully considered, and even details were settled, but it failed to pass the Legislative Council.

It is unnecessary, however, to record all the attempts, official, semi-official or amateur, that have been put forward from time to time; suffice it to say that none has succeeded in pleasing all parties, all have failed, and the development of a producing oil-field in Barbados remains an interesting possibility.

Here, then, we have Barbados, one of our oldest Colonial possessions, and the second to attain to representative government, with an enterprising, intelligent and intensely loyal population, an important strategical position, an excellent system of good roads, a magnificent water supply, a healthy climate and abundant cheap labour. The Colony possesses an asset, which may be of little, but is perhaps of considerable value, entirely undeveloped and at present of no practical use to anyone.

It is here that the voice of Empire should be heard in no uncertain tones. The value of petroleum under war conditions has risen to unheard-of heights, the demand for petrol and fuel-oil is ever increasing, and the world-supply can with difficulty cope with it. There is little likelihood of the price of crude petroleum ever dropping again to its pre-War level, and thus every additional source, however small, must be worthy of consideration.

If this war has taught us anything, it has made clear the necessity of Imperial development, and the opening up and co-ordination of our resources, whether in this country or in our

oversea Dominions and Colonies. We can look forward with the eye of faith to a time when every British possession will be given its individual work to do, and will be called upon to furnish its quota of indigenous products to the general Imperial welfare.

In such an Imperial co-operation each British oilfield's duty and right would be to deliver according to its ability so much petrol, so much lubricating oil, so much oil-fuel annually for the needs of the Empire. Every British country that can produce oil, either crude petroleum or the product of distillation of oil-shales and cannel coals, would be assessed upon its possible output, and directed to deliver, or keep in storage, the quantity of oil of the required specification for Imperial needs, not only for a peace-time consumption, but for a provision against the needs of any future war in which the Empire may be involved. And in such a scheme the necessity of developing every British source of these essential products would be fully recognised and insisted upon. The talent hidden in the ground, it will be remembered, brought neither profit nor credit to its timid owner; even "that which he had" was taken from him.

Is it, then, too much to hope that Barbados will realise the Imperial importance of its buried treasure? With the bold example of this country before their eyes, this old and apparently fully-developed country, where supposititious stores of crude petroleum, still undiscovered, have already been claimed in defiance of owners' rights as Crown property, surely the shrewd Barbadians may be induced to take a broader view of the question of petroleum development. The prospects of establishing an oil industry are far brighter in the West Indian island than anyone would dare to suggest of the possible oilfields of Great Britain.

Some scheme, even if involving a measure of compulsion, can surely be drafted, some sacrifice of insular ideas can surely be made. Barbados waits for the drill; the need is now, and the means to satisfy it will not be far to seek.

Twenty-Seventh General Meeting.

A Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, on Tuesday evening, 15th January, 1918, Mr. Charles Greenway (President) occupying the Chair.

The Members of Council present were Messrs. A. Campbell, E. H. Cunningham Craig, Arthur W. Eastlake and T. C. Palmer, Dr. F. Mollwo Perkin and Sir Boverton Redwood, Bart. A message of regret for unavoidable absence was received from Professor John Cadman.

The President, in opening the meeting, said that he had much pleasure in inviting Captain Masterson to read a paper on "The Petroleum Industry of Rumania." Members were probably aware that Captain Masterson was one of the band of patriots who, at the risk of their lives and in imminent danger of capture, undertook the destruction of the wells and refineries of Rumania, in order that the enemy might not secure any immediate benefit from the chief objective of their advance. All would be pleased to see that Captain Masterson's services had been recognised by the bestowal upon him of the Order of Distinguished Service. Captain Masterson's knowledge of the Rumanian oilfields was very great, and the speaker was sure that members would listen to his paper with deep interest.

The following paper was then read :—

The Petroleum Industry of Rumania.

By Captain T. S. Masterson, D.S.O., *Member*.

When asked to read this paper on the Rumanian Oil Industry, the author undertook the task with a light-heartedness which he has since had cause to regret. As soon as he gave further consideration to the form which the paper was actually to take, the choice between the variety of aspects from which the subject could be treated presented a problem of overwhelming difficulty, as any account of the oil industry is necessarily incomplete without a consideration of all the phases in which the industry has to be carried on. From the practical point of view, with which, of course, we are mainly concerned, questions of concessions, labour, efficiency of plant, disposal of products, etc., are as important as the location, distribution and extent of the deposits themselves. Any one of these features was capable of detailed treatment, and the difficulty was to decide between them. This was, however, solved by the fact that any discussion of them, to be of permanent value and worthy of a place in the Institution's Journal, required

to be based on statistical data of a fairly complete character, and his somewhat precipitate departure from the fields had left the author inadequately supplied in this respect. The paper, therefore, takes rather the nature of a general sketch, in which the main features of the various aspects are noted, including some remarks on the state of the land tenure as it affects oil concessions, and which it is hoped will suffice to furnish a general outline of such conditions and development as existed before the invasion of 1916. This will readily lend itself to amplification by any members of the audience who are familiar with the Rumanian oilfields, and will, perhaps, prove of greater interest to those who are not so, than would a more specialised consideration of any single aspect of the industry.

Geography. Rumania, situated in the south-eastern part of Europe, is identified by the crossing of the 45th parallel of north latitude with the 25th meridian of east longitude. The Danube and a line from Turtucaia to Baltchick in the Dobrudga form the southern boundary. A line through a number of the highest peaks of the Carpathians from Turnu Severin to Burdujeni forms the northern and north-western frontier. The River Pruth and the Chilia branch of the Danube form the frontier towards Russia. The Euxine seaboard from Chilia to Baltchick, a distance of 185 miles, closes the eastern boundary. The harbour of Constantza, together with the ports on the Danube, constitute the principal outlet for Rumanian produce of all kinds, the westward-bound sea freight going through the Dardanelles.

From the Transylvanian border the Carpathians gradually descend on to the plains, forming a mountainous belt of about 35 miles in width. In Wallachia, the southern half of Rumania, when once the plains are reached they stretch to the Danube almost without undulation, revealing extremely rich agricultural soil. This part of the country is watered by a number of short streams, which either originate in Rumanian territory, or come from Transylvania through deep gorges in the Carpathians. These streams all eventually run into the Danube, and with one or two exceptions are more or less of a torrential character.

Moldavia, the northern province of Rumania, is cut longitudinally by the river Sereth, which comes from the Bukowina watershed, its course being almost due south. On its way it gathers all the streams which originate in the Moldavian Carpathians. The Sereth was at one time navigable, but in recent years it has been only used for floating down timbers from the mountain forests to the Danube, from whence they were exported.

Climate. Owing to Rumania's proximity to the Black Sea and the Russian Steppes, with no hills intervening from which shelter might be gained, she does not enjoy the temperate climate which her geographical position would indicate. The winters are usually cold, the glass often falling below 0° Fahr., whilst the summers are intensely hot, and 100° Fahr. in the shade is not uncommon. In the vicinity of the oilfields, however, the climate is more temperate, owing to their comparatively sheltered positions. The Springs are short and usually inclement, but the Autumns are long and beautiful, and it has truly been stated that the Rumanian Oilfields are amongst the most healthful in the world. They are situated at altitudes varying from 500 to 2,000 ft. above sea level.

Communications. Rumania, in normal times, could be reached from London in 2½ days. Wallachia is served by a single line from Verciorova, where it leaves the Hungarian frontier, eastward to Bucharest, the capital, from whence it continues to Constantza. This line is fed by a number of branch lines coming down from the mountain regions, and others coming up from the Danube ports. Moldavia is served by two main lines running due north, and these are connected to branch lines coming from the more important Carpathian valleys. The Rumanian system is linked up with Austria-Hungary by five lines, with Russia by two lines, and with Bulgaria by one line.

The main roads or national causeways are metalled and in good condition; they are very wide and bridged, and motor-cars can comfortably travel over them in all seasons at the rate of 40 miles an hour. The branch roads are narrower, and, although metalled, they are not well kept. Motor-cars travel over them at the rate of 20 miles an hour. The rivers, not always being bridged, have to be forded when the water is not too high. The oilfields, with the exception of Campina and Baicoi, which are right on the railway, are located at a distance of from 7 to 25 miles from the nearest station. The roads leading to most of them are of inferior type, and therefore access during rainy weather is not always pleasant. The authorities have not grappled with the road problem which the additional heavy traffic of an oilfield imposes. The condition of the roads through the oilfields proper largely depends on the efforts of the operators, and unfortunately not all have realised that proper roads through the fields are essential to the success of efficient oil mining. The surface soil on the Rumanian fields consists of a very sticky clay. Non-metalled roads turn into hopeless mires after two or three rains, and it is not uncommon to see a number of wells shut down waiting for the roads to improve.

Mining Rights. The subsoil, as far as oil is concerned, is the undisputed property of the surface-owner. The Mining Act, which became law in 1892, does not interfere in any way with the ownership or exploitation of the oil, but subsequent orders, enforced in 1900 and 1904, regulated the operations, their general tendency being to ensure an economic exploitation, with certain safeguards relating to the distance between one well and another, and also their distance from bordering plots. Provision was also made against flooding the oil strata, and for the safety of labour.

Land Tenure. With few exceptions the land before 1864 belonged almost entirely to the monasteries and the landed proprietors. The great majority of the peasant class were serfs. In 1864, however, the Government seized the monastic properties, freed the peasants, and granted them over 3,000,000 hectares of land in small holdings not exceeding six hectares, or about 15 acres. The laws which relate to succession of property, by which sons and daughters share equally in the parental inheritance, has, in a great measure, contrived to reduce these plots to very small strips, and particularly is this noticeable in the oilfield region, where the average size of the plot is not larger than one acre, and where even a fairly large sprinkling of plots not exceeding one-quarter of an acre is quite common.

The properties as they exist to-day can be divided into three categories:

(1) State land, including land held by State Institutions, such as hospitals.

(2) Landed property owned by the Boyars, or the large proprietor class.

(3) Peasant property:

(*a*) Rural land obtained in virtue of the 1864 and subsequent laws as described above.

(*b*) Mosneni or Elders' land which has been passed down to the present owners without any apparent title. The boundaries of this last type of property are identified by some accidental object such as a tree, a ridge or a stone (which often gets shifted), and disputes are settled on the basis of depositions by witnesses.

The Geographical Department of the Army has surveyed all the land, and general maps on good working scales can be obtained, but there is no cadastral map showing the ownership.

The peasant land, which forms the bulk of the petroleum concessions, consists of the two varieties mentioned above, but the oil concessionaire was always confronted with the difficulty of getting

a good title. In the case of the "Mosneni" land, with no documents to prove the ownership, the truth could only be ferreted out by those with intimate local knowledge. For competitive reasons the concessions were usually taken up in a hurry, and in consequence many were taken from the wrong parties. More or less the same conditions applied to the rural type of peasant land.

Although the ownership in 1864 or 1881 could be established, the land had since been so much subdivided, and very often without legal record, that the finding of the rightful owner was always an arduous matter, and frequently led to the cancelling of concessions. Secret connivance amongst the peasants and the intermediaries increased the difficulties. A large number of concessions were thereby involved in expensive and interminable lawsuits.

The position became so acute that in the year 1904 the Government brought in a law to protect the concessionaire. This was the law of Consolidation, by which the concessionaire was given the opportunity of sending a survey of his plot to the president of the local tribunal, with a request that it should be given a legal status. The president published the request, and exhibited the map, calling on parties who might have other rights on the property to appear and substantiate their claims. The tribunal thereupon gave its decision or, failing any contestations, the plot was automatically "consolidated." In other words, the concessionaire obtaining such an additional deed to his title was thereafter protected against other parties. It was thought that by this method an unassailable title might be obtained.

The new procedure was, it is true, a decided improvement on the old conditions, but fraud and blackmail still prevailed, and it was even possible for the same plot to be consolidated twice or three times over by two or three different parties, with comparative immunity from punishment for the offenders, with the result that the decision of a consolidation tribunal could not necessarily be regarded as giving a guarantee of security of tenure. The aw was gradually and favourably amended, but the position in 1916 was still not completely satisfactory.

Geology. Oil is found in the Tertiary rocks skirting the foothills of the Carpathians. The immediately adjacent plains are covered with thick terraces of gravel. These reveal but few indications which might assist the geologist, and for this reason the plains have not yet been tested.

The largest deposits of oil discovered are contained in the Pliocene series, although important quantities have also been found in the Oligocene and Eocene, notably in the old Bustenari field and

in Moldavia at Moinesti and Solontz. The Salifère of the Miocene has been found to contain oil in commercial quantities only at Tetzcani in Moldavia.

Geologists have already described the geology of Rumania, and it is here intended to draw attention only to the coincidence of the concentration of oil in beds which, conformably or otherwise, are in contact with the Salifère of the Miocene.

Mrazec, prior to 1907, emitted the theory that under favourable conditions oil was formed in the Salifère, which he described as the "Roche Mère" of the Rumanian oil. He also contended that the Salifère beds usually being unfavourable for accumulation and retention, the oil, under the influence of earth movements, invariably migrated into other beds offering more suitable features for accumulation and retention. It will, perhaps, be of interest to see in the light of subsequent discoveries how far this theory is supported by evidence.

In recent years the important flexure between Tzintea and Rasvad, along a distance of about 25 miles, has received much attention; and oil in large quantities has been newly discovered in such localities as Moreni Bana, Rasvad and Filipesti. These discoveries were not always due to tests based on the "Salifère" theory; but the results obtained showed that the reluctance in accepting the theory at the outset really delayed the discovery.

Moreni Bana and Moreni Stavropoleos-Tuicani.

These two fields are separated by the Salifère upthrust as shown lower down. The Stavropoleos-Tuicani extension is the richest field so far discovered in Rumania, and the first well was the subject of much controversy, inasmuch as the very authority which should have supported the selection of the site—based on the said theory—opposed it. In the lower end of the field depths of 2,500 ft. have been reached, and very prolific sands have been tapped. In this part, the Dacian series is still not penetrated.

Nearer to the fault, the Pontic series has been entered by the drill in some two or three borings, but the work was abandoned before the Pontic was drilled through. The Pontic series in the whole area under consideration consists of somewhat sandy marls. They do not contain well-defined beds, suitable for the concentration of oil, but it is highly probable that when the Pontic is penetrated, the underlying Mæotic sands will be found to contain oil.

At *Moreni Bana*, where the exploitation work, with two notable exceptions, is situated upon the north side of the Salifère intrusion, the upper Pliocene beds of the syncline were also found

to contain oil in the beds of sand which were in contact with the Salifère, and which were protected from inspissation. This syncline is a relatively small one, and after a short period of exploitation the oil was more or less exhausted. A few borings on being deepened revealed the sterile Pontic, and were abandoned. For some time after, the Companies owning land in this part of the field had not a bright prospect before them.

In 1913 the Rumanian Consolidated Company drilled through the Pontic with a view to testing the Mæotic sands. At 2,230 ft., after drilling through about 1,400 ft. of uniform Pontic marls with no variation beyond that of some portions being a little more compact and harder than others, a thin sand containing oil was found soon after the Mæotic series was entered, and 100 ft. lower another sand was found yielding fountain oil.

It is also of some interest to add that at Moreni Bana the Pontic marls frequently contain eyes or small balls of sand $\frac{1}{8}$ in. to 1 in. in diameter. In the vicinity of the Salifère upthrust, these eyes are charged with oil. To a certain extent the marls are also oily.

Filipesti is situated along the same line of flexure. No Salifère upthrust has so far been observed, but it is quite possible that future prospecting may disclose the existence of an upthrust to the south of the present exploitation. The oil now produced is obtained from the Mæotic series, which conformably overlies the Salifère. The upper Pliocenes which have no contact with the Salifère contain no trace of oil.

Gura Ocnitei, *Rasvad*, *Baicoi* and *Tzintea* are producing fields on the same line of flexure. Salifère intrusions, similar to the one observed at Moreni, are the prominent features of these fields, and oil is similarly concentrated in the younger Pliocene beds which have been brought into contact with the Salifère. A deep well sunk at Gura Ocnitei through the Pontic and into the Mæotic successfully proved the existence of oil much in the same conditions as it was found in the Mæotic at Bana-Moreni. The characteristics of the Pontic were also similar.

The Salifère upthrust is not continuous along the whole line of flexure. Thus at Moreni the rock salt of the Salifère, if there is a continuation of it, ceases to be dislodged from its original seat; at any rate, no further Salifère intrusion is observable at a point approximately 100 yards west of Boring No. 2 Astra Romana. Almost simultaneously the upper Pliocene rocks cease to contain oil, and the borings No. 1 and 2 of the Romana Americana at Piscuri were drilled through Levantine and Dacian beds to depths exceeding 2,600 ft. without revealing any deposits of oil.

Similarly at Floresti, between Baicoi and Filipesti, where the Salifère intrusion observed at Baicoi apparently ceases to continue westward, the Astra Romana Boring No. 2 which was drilled to 1,600 ft., failed to find any deposits of oil in the upper Pliocenes, although perhaps the boring is not sufficiently deep to decide the point at issue. The chances of success in the search for oil at reasonable depths in the upper Pliocene would therefore appear, in the belt under consideration, to be limited to the area of the fault which has brought the younger beds into contact with the Salifère.

Development. In the early days of the industry the oil was obtained by means of hand-dug shafts, which were worked in large numbers along the outcrops, where the oil was found at shallow depths. This hand-well industry presented a remarkable spectacle, and in localities like Bustenari hundreds of shafts could be seen at work in all directions, giving the impression of a veritable human beehive.

The hand-shafts were of two kinds. In Moldavia, where the beds are not so steeply inclined, and consequently less liable to cave, round holes were dug, having a diameter of about 3 ft. They were lined with twigs or tree branches in the form of wicker-work. In Wallachia, where the hand-shafts were sunk in steeper beds, it was found that the round hole and wicker-work lining as used in Moldavia would not resist the lateral pressure of the beds, and square holes 3 ft. 6 in. by 3 ft. 6 in. were resorted to. These were lined with 2 in. oak or beech timbers, which often yielded in the centre, and had to be replaced.

The excavated matter is brought to the surface in buckets, which are lowered and raised by means of gins installed at the mouth of the shaft, and are worked either by man or horse traction. When the first oil source is reached, and exhausted or reduced to a quantity which no longer pays, the shaft is deepened to a second, third and even fourth source. Some of them actually reach depths exceeding 900 ft.

The work of excavation is carried out by a digger known as the Putzar, who digs at the bottom of the hole, and is tied to a hemp line connected to a gin at the mouth of the well. Fresh air is pumped down to him by means of a primitive bellows connected by 8-in. tin tubes. The digger is covered with leather skins, and wears a tin hat, as oil from the upper sources is continually dripping or running on him. In this condition he works three or four hours at a time, sending up bucket after bucket of the rock he digs with his pick. It is the practice to blast thick beds of sandstone.

There is always the danger of suddenly striking an oil source,

and to avoid this possibility a ⅝-in. sounding rod is driven 10 or 12 ft. below the level at which the digger works. If an oil source is encountered, it at once issues forth through the small sounding hole, and the digger has time to make his escape. But in spite of these precautions it often happens that when an oilsand is approached, the gas pressure breaks the intervening rock, and large quantities of oil and oilsand issue, completely burying the digger, who often remains for months in the position in which he is caught, until the level of the oil is reduced and the sand cleaned out, after which his body is removed.

The oil is extracted by means of two wooden buckets or leather skins, one being lowered empty while the other is raised full. By this means as much as 18 to 20 tons of oil have been extracted in 24 hours from depths of about 500 ft.

The handshaft industry was completely dying out in 1916, when only a few new hand-wells were being dug by the peasant class of operators.

Mechanical development on a more or less serious scale began after the year 1898, owing principally to the influx of foreign capital. The industry progressed with rapid strides, and the following are the fields which developed in rapid succession and from which most of the production was obtained:

		Production for 1915. Tons.
1	Campina	120·657
2	Bustenari and Calinet	129·954
	,, Chiciura, Gropi and Tontesti ...	66·063
	,, Bordeni and Recea	53·642
	,, Runcu	36·376
3	Tzintea	92·480
4	Baicoi	178·060
5	Gura Ocnitei	69·781
6	Moreni	741·163
7	Arbanasi	107·555
8	Filipesti	8·279
9	Rasvad	28·437
10	Moinesti, Solontz and Zenies	17·874

Other oilfields producing less significant quantities were—Copaceni, Pacureti, Apostolache, Ceptura, Colibasi and Glodeni, Sarata and Berca, Tetzcani and Campeni.

The following is the progress of the total Rumanian production during the last 12 years:

1904	500,561
5	614,870
6	887,091
7	1,129,297
8	1,147,727
9	1,297,257
1910	1,352,407
1	1,544,847
2	1,804,761
3	1,885,225
4	1,783,947
5	1,673,145

In the year 1915 the whole industry comprised about 2,100 borings, of which

48 % were more or less productive.
18 % „ drilling and repairing.
34 % „ held in suspense or abandoned.

Drilling. In the early days, between the years 1886 and 1888, the first drilling was done at Draganeasa on the Cantacuzene property, and in Moldavia at Harsa on the Negropontes property. Both fields were drilled on the Pennsylvanian system, and the sites of the borings can be seen to-day. At Harsa, small 4-in. and 5-in. pipes are sticking out of the ground, indicating the old positions, and the same may be seen at Draganeasa.

With one notable exception, these borings were technical failures. In the first locality, the borings never got deeper than 1,000 ft., and at the last only one or two got beyond that depth. They either went out of plumb or became too small in diameter. It was found that the Pennsylvanian system, as adopted for the rocks of Pennsylvania, would not work, as the beds would not stand up in the drilling unless the casing followed closely.

Next to be used was the Canadian system, which "made good." At first very slow progress was made on account of the constant need of using the under-reamer, but later, in 1898, with the more general introduction of the eccentric bit, better progress was made, and the Canadian system has lived down to 1916, partly because of its steady, although slow, progress, and partly because of the preference shown for it by some operators who do not altogether trust the water-flush systems. A third factor responsible for the persistence of this system may be found in the enormous quantity of Canadian boring material and tools which had accumulated,

and operators were therefore naturally reluctant to purchase new plant.

Various types of water-flush percussion-systems were used after the year 1898—including the Vogt, Treschl, Travzl and Marenholz which are on the same principle, but differ only in details of construction. For a number of reasons, not excluding local prejudice, these systems failed to make a permanent stay. They were chiefly used by contract drillers, and Company Managers generally did not favour them. It was only in later years when certain Companies purchased their own plant, such as the Astra Romana and Steaua Romana that the water-flush percussion-system came in for permanent use, and in particular the "Alliance" rig used by the Steaua Romana was a notable success.

In 1904 the Pennsylvanian system was again introduced, this time by the Standard Oil Company, who sent out a large consignment of drilling plant, and a number of American drillers. It is curious to notice that, with the exception of its being of a heavier type, the same kind of plant was sent over as had proved a failure in 1886, and the same method of drilling was adopted. During the first few years only a few successful wells were drilled, and the majority, for technical reasons, were abandoned before the oil strata was reached.

It was found that casing, including the heavier type of "drive pipe," would not drive successfully through gravel or sands, and, indeed, at depths exceeding 1,000 ft. the casing would not drive at all. Calf wheels were introduced, under-reaming was resorted to, and eventually, three years later, after variable experience and much expense, which would have broken ordinary Companies, the Pennsylvanian system became a success, but not until it had been adapted for manipulating and inserting casing *pari passu* with the advance of drilling.

The water-flush percussion-systems in the early days, when clear water was used for flushing, were subject to the same disadvantages, and casing had to follow the drill in the same way as with the dry systems.

In 1904 or 1905 the first rotary system was introduced at Apostolache, but, partly because the plant brought out was of too light a pattern, and partly because the rock in that particular region was not of the most suitable, these first efforts were failures.

Later, in 1912, the rotary was again introduced, but, for reasons more of an administrative nature, there was again no success. The following year, however, the rotary was given a fair trial, and in suitable rock it proved a success, and the rotary will very likely be

more widely employed in the future. The special advantages offered have been discussed at length, but verdicts in support of one or in detraction of another system are often too general.

The rotary in Rumania has been a great success in the soft loose sandy marls of the Pontic beds between Gura Ocnitei and Tzintea. The use of thick mud-flush has made it possible to drill 1,600 ft. of uncased hole, and at Bana-Moreni wells have been drilled to 2,400 ft., at an average progress of 65 ft. per day, including the time needed for the setting of two strings of casing, and the exclusion of the water in the upper sands. This record compares very favourably with the achievements of the percussion flush systems. Daily drilling records of 250 and 300 ft. of 12 in. hole have been frequent.

In the sandy and small-gravel beds of Tuicani, the rotary has also shown an advantage over the percussion-systems, but in the beds of larger gravel and boulders the progress was less favourable, whilst in the conglomerates at Baicoi, and in the sandstone at Chiciura and Gropi, progress has been very slow, the amount drilled in 24 hours often not exceeding 14 in., a progress not equal to that obtained with the percussion-systems.

This may have been due to the inferior kind of steel available for the bits, which could not be hardened sufficiently. They became blunt after ten minutes' use, and any longer rotation had the effect of reducing the bit rather than cutting the rock. It was found that in hard gritty rock the best progress was made by pulling out and changing the bit at the closest intervals.

It was also found, where big holes were drilled through hard sandstone, that ledges were left on the rock, which held up the casing when it was inserted, and reaming had to be resorted to, which operation very often required the same amount of time as the original drilling. Guides above the bit did not always exclude this trouble, although they were dangerous tools to have in the hole.

The Sharp & Hughes bits were not sufficiently tested—for one reason because suitable sizes were not available, and no others could be introduced owing to the war conditions.

The combination-rig, that is the rotary and ordinary percussion-system, has not proved satisfactory where hard shells are met with at frequent intervals, inasmuch as one of the great advantages obtained by the rotary, namely that of saving casing, was lost because, in the absence of thick mud-flush, casing would have to be inserted before the mud in the hole was thinned and made suitable for cable or solid-rod drilling.

The author devised a method for overcoming this difficulty by the addition of a bullwheel to the rotary derrick, and the addition of a crank to a lengthened drilling shaft, with the object of using hollow flush-poles for spudding through the hard shells. The advantage of the arrangement consists in not over-burdening the derrick, as would be necessary in the case of the introduction of the walking-beam, and secondly in so far as the continuation of flushing with the same mud as used for rotary drilling makes it unnecessary to insert casing. Another advantage afforded is that no loss of time is involved in the change from one system to the other.

It has been stated that the rotary, by its speed through sand and the heavy weight of the flush-mud, frequently allows oilsands to be drilled through and "mudded off" without being observed. Of course this is possible with the rotary as with any other system—perhaps more so with the flush systems, for in the case of thin oilsands, the sand which is flushed up is often mixed in such small proportions with samples of the preponderating rock that the sand can hardly be identified.

In any case the sample is not so pure as that brought up in a baler from the bottom of the hole in the case of percussion non-flush drilling. But vigilance is necessary with any system, and many an oilsand has been drilled through undetected even with the Canadian and Pennsylvanian systems. With a certain amount of vigilance no oilsand need be passed unobserved, even where there is no big gas pressure.

In addition to the wells which came under the author's personal observation, he has made enquiries as to the results obtained from most of the rotary bores in Rumania, and it may fairly be stated that all oilsands can be detected by vigilant and experienced drillers. The oil contained in the thickness of the sand penetrated usually comes up to the surface, and the fresh lively oils thus displaced can hardly be mistaken for the grease or dead oil that might have got into the flushings as a result of oiling of the machinery parts. Shows of oil from an upper source which it is intended to neglect are also mudded off if circulation is not lost.

Where the oil is struck at low pressure or in partly exhausted sands, an immediate loss of the flush water is observed, which gives the needful indication to those in authority to decide as to whether a test is necessary or not.

There is one more point worthy to be added in favour of the rotary, and that is that on account of the mudding up of the walls, it facilitates the shutting off of water, particularly when the hydrostatic pressure is not great. Where the annular space

behind the casing has to be washed for the purpose of using cement this advantage is lost.

It is evident from what has been said that no one system can be generally advocated for Rumania, each system having its advantages and disadvantages. Before selecting the plant for drilling in an already exploited field, existing data suffice to ensure the best choice. In unexplored fields the percussion-system is advisable, as the operator is very often unacquainted with the characteristics of the rock to be drilled.

Labour. American drillers came over in 1886, but left Rumania when the borings which they had been brought out for were stopped. With the advent of the Canadian system all the skilled labour was imported from Galicia. Polish drillers and aids came over in large numbers until the year 1904, when native Rumanians who were being employed in increasing numbers gradually replaced the Polish labour, and in 1916 nearly all the Canadian rigs were run by natives, as were also those operated on the Pennsylvanian system. The first work was conducted with American drillers and tool dressers, but in the last two or three years natives were replacing the Americans, who were given the work of supervision. The rotary drill, although only of recent advent, was being manned largely by Rumanians.

The Rumanian peasant, who is superseding the foreign driller, is an intelligent and conscientious worker, but lacks education, which makes it difficult for him to grasp mechanics. This is easily understood when it is remembered that Rumania is essentially an agricultural country.

Supply of Materials. The timber for derricks and all buildings is supplied from the large forests in the Carpathians. Cement and refractory materials are also made locally, but all metals and textile manufactures are imported.

Germany supplied the entire requirements of casing, tank plates, electric plant and refinery commodities. With a very few exceptions Germany also supplied the pumping and workshop plant. In addition to this, Germany supplied the raw materials used by the local workshops for manufacturing rig irons and drilling tools. England's share in these supplies was altogether insignificant, and what English material was used was due to the patriotic impulse of a few Britishers. It is understood that funds, to be supplied by the Allies, will play an important part in the restoration of the fields, and it is to be hoped that the necessary safeguards will be taken to ensure that no Allied money finds its way into Germany as purchase price for materials needed for the reconstruc-

tion. As mentioned above, Germany in the past supplied practically all the materials. Let us be prepared to do so this time.

Refining, Storing and Transport. To do justice to this subject it would require a special treatment, and as enough of your time has already been taken up this evening, it is here only intended to mention that Rumania had 61 refineries, in which a total of 4½ million tons of crude per annum could be treated as compared with 1·9 million tons, which was the highest production of crude obtained in one year. 85 % of the refining capacity obtained in 11 of the largest refineries, situated in the following centres:

1. Ploesti. 2. Campina. 3. Tergoviste.
4. Baicoi. 5. Buzeu. 6. Plopeni.

The total capacity of iron tankage available at the producing fields, refineries and storage stations, was 1,450,000 tons.

The crude oil was brought down to the refineries or loading stations by means of a large number of pipelines, varying from 2 in. to 6 in., and the longest line not exceeding 45 km. The total length of all the pipelines is 1,300 km. To this must be added the State lines leading from the oilfield centres to Constantza on the seaboard, which were not complete when the territory was overrun by the enemy. For internal distribution and for conveying the export to the seaboard or Danube ports, 4,200 tank wagons were used.

Rumania entered the war in August, 1916. In November of the same year, the oilfields were destroyed, with a view to deprive the enemy of the advantages which they undoubtedly would have afforded. Huge stocks of oil were destroyed, and the tankage was blown up. The wells and refineries were subjected to the maximum amount of damage and destruction which the short time available permitted, and it was the author's painful duty to be amongst the last to see the flames consuming an industry the building up of which he had witnessed almost from its inception.

On re-occupation of her territory Rumania will be confronted with one of two conditions:

1. Either the industry will be found in a state of greater destruction than when it was left in December, 1916, or

2. It will be found with such improvements as may have been effected under the German occupation.

In either case the interested parties will be faced with the problem of reconstruction, and we all hope that the Rumanian Government will avail itself of that opportunity for removing the difficulties connected with land tenure which have so seriously hampered the industry in the past.

DISCUSSION.

The President remarked that the members were extremely indebted to Captain Masterson for his very interesting and instructive paper. Personally, he had been most attracted by those parts of the paper which dealt with the development of the Rumanian oilfields, and with the results of the various methods of drilling used in them. Notwithstanding the success of the rotary method emphasized by Captain Masterson, the impression left on the speaker's mind was that, in Rumania as well as everywhere else nothing was so certain and reliable as the good old Canadian method, and on that point members might be willing to give their experience and views.

If Captain Masterson were in a position to give it, information would be desirable as to the estimated average cost per ton of raising crude in the Rumanian fields. The author had stated that, in 1915, the total number of borings amounted to 2,100, of which 48 %—or about 1,000 wells—were more or less productive. That number of wells, divided into the entire production of 1915, worked out at an average of 30 barrels daily. If the large number of unproductive wells were taken into account, the average would work out at only about 15 barrels daily. As compared with other fields, it appeared to the speaker that the cost of working the Rumanian wells must be very high, and it would be both instructive and valuable, from the national point of view, if Captain Masterson could give some idea of the average costs, inclusive of royalties, rents and all expenses up to the delivery-pipe.

He assumed that the quality of the crude had not varied appreciably from what it was a few years ago, when the specific gravity was about 0·824 to 0·840, with a large percentage of benzine and kerosene in the yield.

Captain Masterson's description of the hand-wells was interesting as corresponding very closely with the methods which had been followed by the twinzas in the Burma oilfields from time immemorial. In this, as in so many other matters, the East had given a lead to the West.

Mr. W. E. Guttentag desired to thank Captain Masterson personally for his paper. He had experienced considerable difficulty in finding any literature in English bearing on the Rumanian oilfields when, some years ago, he had attempted to make a study of them, and Captain Masterson's paper was, he believed, the first piece of such literature devoted entirely to the

subject. He could only hope that the paper would form the nucleus of a literature that would make the Rumanian industry more familiar to people in this country.

One point which he regarded as of interest to the Institution, particularly to the Council, was the educational value of the Rumanian oilfields. Speaking relatively, these oilfields were in fairly close proximity to civilisation, and were comparatively easy of access from London. That being so, he thought they might well form an excellent opportunity for the establishment of post-graduate courses, and, if it were the intention of the Institution of Petroleum Technologists to follow the scheme adopted by the Institution of Mining and Metallurgy, the suggestion should be worth consideration. He might mention that the Dutch firms having oil workings in Rumania sent thither their young men, trained in the Universities, to get practical experience. When these men were able to pass the Government examinations out there, they were either retained in Rumania, or were sent to other parts of the world in which Dutch firms had oilfields. In that way there was never any lack of staff.

He believed that the legislation in regard to the Rumanian oilfields was based upon the Galician code and practice, and was therefore probably a model system of oilfield and oil-mining legislation. In carrying out the legislative regulations, it had been assumed to be essential that the master drillers should be men of some little intelligence, and at Câmpina a school had been instituted for master drillers.

With regard to the sampling of rotary muds, the speaker wondered whether Captain Masterson had come across an automatic scheme for such sampling. He believed the Astra Romana were much interested in some scheme of the kind. There was in many fields a thin band of yellow clay just above the oilsand which served as a guide by drillers, if it were not missed.

With reference to the past history of many of the Rumanian fields, he thought that anyone trying to get model data would find himself greatly handicapped by the impossibility of relying upon the logs, which were in a fearful state of confusion. He mentioned particularly the Berca-Beciu-Arbanasi field, which was interesting as having, probably, one of the simplest structures in the country, and as possessing mud volcanoes, which may have caused this field to be among the first to attract attention. The structure was anticlinal, about 12 kilometres in length, and very nearly straight. For about twenty years some twenty hand-dug wells were sufficient to keep Buzeu just alive. Moreover, bad

administration had, in the past, been responsible for the feeble results from this field. It was interesting to observe that the wells in which the greatest difficulty was found were fairly close to the mud volcanoes. In 1916 the Standard Oil Company were putting down a well southeast of the Berca anticline, but when he left the country the sinkings had not been deep enough to afford any valuable information; the circumstance, nevertheless, showed that there was some hope entertained for that district.

As to the quality of the Rumanian oils he would submit one or two notes. The colour, particularly in the Berca district, was usually a fluorescent green, while the specific gravities recorded ranged usually from 0·780 to 0·870, excluding the cases of "freak" oils. He had used one of these light oils in an oil-engine in one of the fields in place of benzine. He had analysed some of the first samples of oil from the Rasvad field. The specific gravity was 0·8859, and the samples had 15 % benzine, 14 % of burning oil, 12 % of gas-oil, and 59 % of fuel-oil. These, of course, were laboratory distillations. He was of opinion that the Dacian oils were more inclined to be asphaltic, and the Mæotic oils to have a paraffin base. In Moldavia, for instance, the oils, which he believed were Dacian, had a specific gravity of 0·850 to 0·860, and others, from more recent exploitations in Mæotic beds, had a specific gravity of 0·800 to 0·810.

With regard to the enemy occupation of Rumania, he rather wondered what the Germans had really obtained. It was regrettable to think that they would get a quantity of petrol. They would certainly not have got much lubricant, as Rumanian oils were not a good source of lubricating oil. The best lubricants, however, produced in the country came from the Vega refinery. He believed these were produced by the vacuum process, but latterly none had been turned out.

On the question of refineries, these were placed, in the Government classification, in three categories, namely, the large, with a working capacity of something over 100,000 tons per annum; the second, with an annual output between 50,000 tons and 100,000 tons; and the third group with an output under 50,000 tons yearly. He believed that in the future the tendency of the refineries would be to migrate toward the sea-board at Constantza; and no doubt the Government pipeline, when completed, would tend to foster that migration.

Mr. L. Hamilton thought that Captain Masterson should be congratulated upon his excellent paper. While everyone present would agree as to the paramount interest of the petroleum industry,

he felt that people who, like the author, had witnessed the birth of a new oilfield, and watched its subsequent development, were very fortunate.

In the case of five or six of the oilfields of Rumania where the beds have been pierced by a salt massif, Tzintea, Baicoi, Moreni, Bana-Moreni and Ocnitza, heavy oil was present. In three of these — Tzintea, Baicoi, Bana-Moreni — there was also fine, light oil in proximity. The association requires some elucidation. He believed that the oil of the Lower Miocene was always of paraffin-base.

The hand-wells in early days were about the only form of exploitation in Arde Pamint, "the burning ground," now called Old Bustenari. They were originally sunk on the outcrop of the Oligocene, the Mæotic beds, which were close by to the south, were considered to be barren, and were only properly developed later, when borings commenced. In both series the oil is paraffin-free. The first oil at Câmpina was got by hand-wells out of the Miocene Salifère, close to the contact with the Mæotic. The first borings there were also sunk in the Salifère, and for a time yielded a pretty good production. Next, the borings were placed farther south, where they had first to perforate the overlying Miocene, before the rich Mæotic oil-beds were reached. The later borings were located directly on the southern flank of the Mæotic. On the northern flank of the Câmpina anticline there was only paraffin-base oil, whereas on the southern flank all the wells, with few exceptions, have yielded non-paraffin oils, but a few have struck a sand with rich paraffin oil. Some of the southern wells have also yielded oils with a very high percentage of benzine. Some one present might perhaps be able to explain the reasons of these anomalies.

Mr. L. Gaster, as a native of Rumania and a British subject, had been deeply interested in the paper in a double sense. Some ten years ago he had attended the Third International Petroleum Congress at Bucharest, and the Government, anxious to do something for the industry, had caused the roads to be specially repaired for the convenience of members of the Congress, that the visitors might the more easily see the oilfields.

Dr. Edeleanu was a Vice-President of the Congress, and had prepared an interesting account of the qualities of the Rumanian petroleum. The *Petroleum Review* gave a translation of this by the speaker. It furnished an account of the oils obtainable at different depths, and the products of distillation. By his investigations, Dr. Edeleanu had been able to improve the quality of the

illuminating and the lubricating oil in such a way that neither the source nor the base was a matter of importance.

The laws relating to tenure of oil-lands had been improved recently, and the introduction of British capital was welcomed, but not the element of the unscrupulous Company promoter, bent on exploiting people's pockets rather than petroleum. If the Rumanian industry is to be properly developed, there must be due understanding of the country's laws, and mutual compromise as to business systems in vogue.

Mr. D. A. Sutherland agreed that the Institution was much indebted to Captain Masterson for his very practical paper. In an account of the petroleum industry of Rumania, written by the speaker in 1899, he mentioned the prevalence of paraffin on one side of the Câmpina anticline and its virtual absence on the other side. The number of machine-drilled wells then existing was 80; at the present day there were something like 2,100. The production in 1888 was only 150,000 tons; in 1915 it was more than ten times that amount. Not only had his prophecy of a great future for the oil industry of Rumania proved correct, but he felt that anyone with the wide experience of that region possessed by Captain Masterson would agree that the country had so far only been scratched, and that there was still an enormous amount of oil to be obtained from it. The comparatively recent discoveries of oil in fresh areas opened up very great possibilities. In the ground newly discovered at Baicoi, and giving a large fountain production, the wells were very expensive, and much money had been lost in drilling them. In 1913 drilling was started near Baicoi station, and here also large production was obtained, one well commencing with an output of 4,000 tons a day.

A large bibliography was appended to the report of the Third Petroleum Congress mentioned by Mr. Gaster, with references to a number of works on Rumanian petroleum written by Rumanians; there was not the slightest doubt that the industry in Rumania had been tackled in a highly scientific fashion.

Although inclined to agree with the President's views on the subject of the rotary system, he was glad that Captain Masterson felt that it would make progress in Rumania. The speaker had had experience of it in the beds at Recea, where there were some 200 metres of clay, traversed in that case in about a couple of weeks. It was a different matter, however, with new fields, and in these he would prefer to use the Canadian rig. In one district in Moldavia it was practically impossible to work the rotary, or any system of the kind, so hard was the rock, and so slow the drilling.

If, as he hoped, the east of Rumania was still available, drilling should be carried on there. Although drilling was expensive, he was confident that a fine class of oil would be found there.

The President desired to explain the object of his question as to the quality of the oil obtained. He had hoped to get some up-to-date information on the point. The literature on the subject was based upon oils produced some years ago. Captain Masterson had only recently left the Rumanian fields, and as he understood that oil had been obtained from lower horizons since the date of that literature, it might have varied somewhat in general character.

Capt. T. S. Masterson, replying to the discussion, dealt first with the President's question as to the cost of production. In two of the more important exploitations, the average cost per ton was 33 lei, or roughly £1 6s., including amortisation and royalty, whilst the average price for crude at the time was 50 lei, or roughly £2 a ton. Operators that could refine their own crude, and sell the finished product, made a better profit. But to obtain the average for the whole country, it would be necessary to have data from all the exploitations. In isolated cases the number, depth and mode of yield of the wells were essential factors. Baling might raise the cost of production to twice or three times that needed in the case of flowing wells.

With regard to the average quality of the oil, the following figures are approximately correct:

	Benzines, light and heavy.	Lamp-oil.
Moreni Bana (upper sources) ...	44·80 %	23·40 %
Moreni Stavropoleus	20·98	23·70
Bustenari	28	27
Filipesti	12·50	28

The oils of Filipesti and Moreni Bana deep source yield about 7 % of paraffin.

As Mr. Guttentag had said, a school had been established in Rumania for teaching drillers, but whilst some good men had been produced, the school had not been long enough at work for a definite opinion as to results. The scheme was a step in the right direction, but the peasant class was not the preponderating element admitted to the school.

The yellow clay mentioned by Mr. Guttentag occurred, as a rule, in the Pontic series about 100 ft. above the junction with the oil-bearing Mæotic, and when present, constituted a sort of local guide.

As to the irregularities in respect of paraffin, the same area gave

oils with a large proportion, and others with little or none, the latter being in the newer beds. But the distinction as paraffin-base and asphalt-base respectively was a somewhat misleading classification, the latter term being applied to oils that had little or no paraffin.

He agreed with Mr. Sutherland that the rotary system of drilling would not be a great success in Moldavia, as there the rocks hitherto drilled were very hard. Not much would, he supposed, be done there until after the war.

In the Baicoi field, an extension of about a mile to the westward was made in 1914, the Roumanian Consolidated Oilfields, Ltd., obtaining a gusher. Over 50 wells have since been sunk there, many being highly productive.

The President closed the proceedings by proposing a very hearty vote of thanks to the author for his able and interesting paper, a suggestion most cordially accepted by the audience.

Mr. R. J. Ward subsequently wrote as follows:—

Although Captain Masterson in no wise committed himself by suggesting the best method of drilling for the Rumanian fields, it is evident from his remarks on the partial success of the rotary system of drilling that, given every chance, better results could be made, more particularly when local requirements are more fully taken into consideration. Having recently returned from the Baku oilfields after four years' work there, I am able to vouch for the good work done by the rotary there, in spite of every obstacle placed in its way. The rotary had its first success some 7 or 8 years ago, but local prejudice, opposition from those heavily interested financially in the free-fall system of drilling, the inability of the American drillers to adapt themselves to local conditions, the constant friction existing between them and the various local administrators, and the difficulty offered by the language, were the causes of many failures. Messrs. Molot, the largest drilling contractors on the Baku fields, with four rotary outfits at work, saw the possibilities of this system, and sent one of their engineers, with a thorough knowledge of local requirements, to America to study the rotary in its native home. On his return, he was given entire control of this branch of the business, with the result that owing to the good work done they increased their outfits to 19. Besides Messrs. Molot, there are a further 15 or so outfits at work in different districts, and it was seen in 1917 that the rotary had "made good." It has had constant successes in Surakhani, Bulbuli, Binagadi, Romani and on the old Balakhani field, so that nothing but "rotary" is

discussed in local engineering circles, and fabulous prices for drilling are being obtained for the producing Companies in their competition to secure the use of the rotary. Unfortunately, this success being so recent, there is a great shortage of screwed casing, drill-pipe, etc., added to the unfortunate chaos now ruling in Russia, all preventing a more general use of this system of drilling. With the advent of Peace, and more normal conditions of working, and the ability to secure the necessary plant, a boom in rotary drilling is predicted for the Baku fields. The success of the rotary, although only recent, proves once more that if it is adapted to suit local requirements and the opposition from bias with which it meets is removed, and the local administrators are better schooled in its method of working, it should meet with the success its adherents claim for it. The troubles of the rotary as enunciated by Captain Masterson, seem much on a par with those met with on the Baku fields, which in the latter case have fortunately been overcome.

Capt. Masterson replies that he has indicated in the paper the kinds of rock for which the rotary and the percussion system are respectively to be preferred. The obstacles to the extended use of the rotary, mentioned by Mr. Ward as overcome in Baku, were of administrative, not of technical nature. If that instrument finds no difficulty in compact gritty sandstone, some detailed evidence of the victory would be valued.

Mr. M. A. Ockenden wrote as follows:—

There are doubtless many who are disappointed with Capt. Masterson's summary of the results obtained by the different drilling systems, but they should all agree with him where he says that no one system can be generally advocated for Rumania, each system having its advantages and disadvantages. Drilling fields already exploited in sufficient data exist for the best choice, but in unexplored ground the percussion-system is preferable.

It is true that the first Pennsylvanian percussion tools in Rumania were not a success, but Captain Masterson inadvertantly remarks that the Pennsylvanian system was made a success later, when really he refers to the *Californian* system. The latter should be regarded as quite distinct from the Pennsylvanian practice, and the driller with Pennsylvanian experience is certainly not to be classed with the Californian driller. The Californian system embodies not only the calf-wheel attachment for handling casing, but many tools and accessories which are unnecessary for the standard Pennsylvanian rig.

In the *rotary* system great improvements have been introduced only during the past few years. Without doubt the rotary with mud-flush will be used extensively in the European oilfields, but, as in America, it will be found that each field will demand slight modifications. From every standpoint it is undesirable to encourage special tools and appliances for every producer, and so prevent standard dimensions in a field. Standardisation of plant, tools and pipe is essential for economical manufacturing and distribution. The interchangeability of material is even more necessary in Rumania than in the oldest fields of the world. Where the manufacturers can be in daily touch with the men in the fields, modifications and a more or less uniform plant can be maintained, but for Rumania, the manufacturers are dependent upon the local requirements, and sometimes vague descriptions, and hence development or change is slow. If each manufacturer were to adopt or encourage all the small and sometimes ridiculous changes communicated to them from foreign fields, there would be great confusion and costly plant, to say nothing of endless fishing jobs.

It would be interesting to learn the result of the circulating system in Rumania with or without mud-flush. For variable formations, this system combines the advantages of the Californian cable-tools and the rotary mud-flush.

As the so-called Canadian system is admittedly slow, it is remarkable that anyone studying British interests should advocate its use after the war. The fact that local lower-grade labour can operate this plant is not sufficient justification to perpetuate a system which retards production of oil.

It is to be hoped that the Allied Governments will not allow Germany or Austria to furnish the bulk of the machinery, pipe, etc., required for Rumania's future development, by unnecessary delays in granting facilities for the preliminary work.

Capt. Masterson replies that:—The Californian oilfields were originally developed with the Pennsylvanian or cable system, but the soft and cavy formation would not allow of the rapid progress being made, to which the drillers were accustomed in the Eastern American fields. Casing had to be used, and as "driving" was not a success, the casing was inserted from the bull-wheels as the drill advanced. This entailed the constant taking down of the drilling cable and the "stringing up" of the blocks and casing line. To avoid this loss of time, which, in many cases, was also the cause of the loss of a string of casing, the calf-wheel was adapted, and with good results. The cable system with this

adaptation was generally referred to as the "Californian pattern." It certainly does not constitute a new system. Moreover, I do not know of any drilling tools that are not common to both patterns, unless it is the special casing-tools which are only more conveniently handled with the calf-wheel than without.

As for the standardisation of drilling tools, I fully agree with Mr. Ockenden in so far as it applies to a system chosen as the most suitable for the field to be operated. The advantages afforded by interchangeability, especially in isolated fields, cannot be overstated, but I cannot coincide with Mr. Ockenden's view that the efficiency of the plant and tools now in use is such as to make it undesirable to encourage new suggestions.

The circulating-cable system was adapted in Rumania by the Standard Oil Company to a small number of its borings. In one instance I know of, it was possible to carry a string of casing deeper by this than with the ordinary method, but as the water used for circulation could not be sufficiently thickened to plaster the walls, without interfering with the drilling, the caving trouble was not overcome. Moreover, the small annular space behind the casing makes it possible for the smallest piece of caving to check the movement of the casing. The greatest advantage furnished by the rotary in soft rock is that a hole can be made without casing having to follow the drill. In this respect it resembles the "dry" percussion-systems in hard rock, such as the limestones of Indiana or Pennsylvania, where the casing is set only after the desired depths have been reached. As regards open-hole drilling, the water-flush percussion with thick mud circulation is the nearest approach to the rotary, and of late, owing to the thickening of the mud, it has been possible to drill a considerable amount of open hole with this system.

A drilling plant which, whilst drilling, ejects the cuttings of the drill, and at the same time makes it unnecessary to insert casing *pari passu* with the advance of the drill, and thereby economises casing, is surely the system of the future, and it is to be hoped that the historical account given in my paper of the Canadian system in Rumania will not be taken as an advocacy of that system.

Periodicity in Spouters.

By W. H. Dalton, F.G.S., F.C.S.

Mental indolence, and the impotence arising from ignorance, combined with false pride, which endeavours to conceal both, too often lead men to assign to engines, wells and other products of man's ingenuity, the wholly human characteristic of caprice, and, by a further exhibition of the vices mentioned, to assign to them a feminine gender. We are not, as an Institution, concerned with the "caprices" of engines, whether actuated by light or heavy oil, but those of oil wells are distinctly within our province. The capacity which many possess of successful handling of "her tantrums" is a very different thing from the scientific grasp of the dominant factors which might, by foreseeing, prevent, or at least more speedily control, the ebullitions.

Unless the statistics of discharge include data which might at first sight appear wholly irrelevant, some important element for the comprehension of the problem may be lacking. Not only the positive spoutings, but any variations, even to increase or reduction of work effected by pumps, are possibly essential data for completeness of conclusion. Conditions of meteorological nature may also have an influence the extent of which can only be estimated by study of full records over a considerable period. It has been suggested, and with great plausibility, that in some fields the rainfall, in others tidal ebb and flow, have a perceptible effect. A still more occult influence is the strain to which the crustal regions of the globe are subjected by planetary attractions when exercised alternately in retardation and acceleration of the orbital movement. Such strains, and the adjustment of the equilibrium disturbed by them, are evidenced by the seismometrical observations recorded in some regions, Japan and Mexico especially, but we are not aware of any attempt to correlate therewith the effect in detail upon oil wells in those or any other countries. It is manifest that these strains would be enhanced in effect by the mobility conferred upon certain regions by fluids under pressure in cavities or porous rocks, and especially fluids of a high coefficient of expansion: a gaol is more speedily evacuated than a hospital

For the collection of the information requisite as a preliminary to a comprehensive dealing with this important topic, the co-operation of members resident in the various oilfields of the world would be of the greatest assistance, and for this reason the foregoing suggestions have been set forth.